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Overview of horizontal directional drilling for utility construction

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A Master's Report Presented to the Graduate Committee of the Department of Civil Engineering as Partial Fulfillment of the Requirements for the Degree of

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Abstract

Horizontal directional drilling (HDD) is a versatile form of utility construction and has seen enormous growth in the last decade as it offers a clear alternative to conventional methods. Drilling is conducted in both the vertical and horizontal direction and can be steered within limits, dependent upon subsurface conditions. HDD can install utilities from 1″ to 48″ in diameter and up to 6000 feet in length. The major utilities (gas, electric, telecommunications and water/sewer) can be installed with this technology. The construction process (pilot hole, reaming and pullback) along with the major components (drill rig, drill pipe, slurry, slurry recycling, survey equipment, drill bits, reamers and pipeline materials) will be discussed. The advantages of cost reduction, and environmental, social and time benefits will be examined in the context of numerous case studies. The challenges of proper soils information, subsurface conditions, training and knowledge, drilling fluids and binding of the drill pipe and reamer/bit will be discussed. Through constant innovation, HDD should remain state of the art for some time, and should be a consideration for the construction of any new utility within the size parameters.

Chapter 1: Introduction

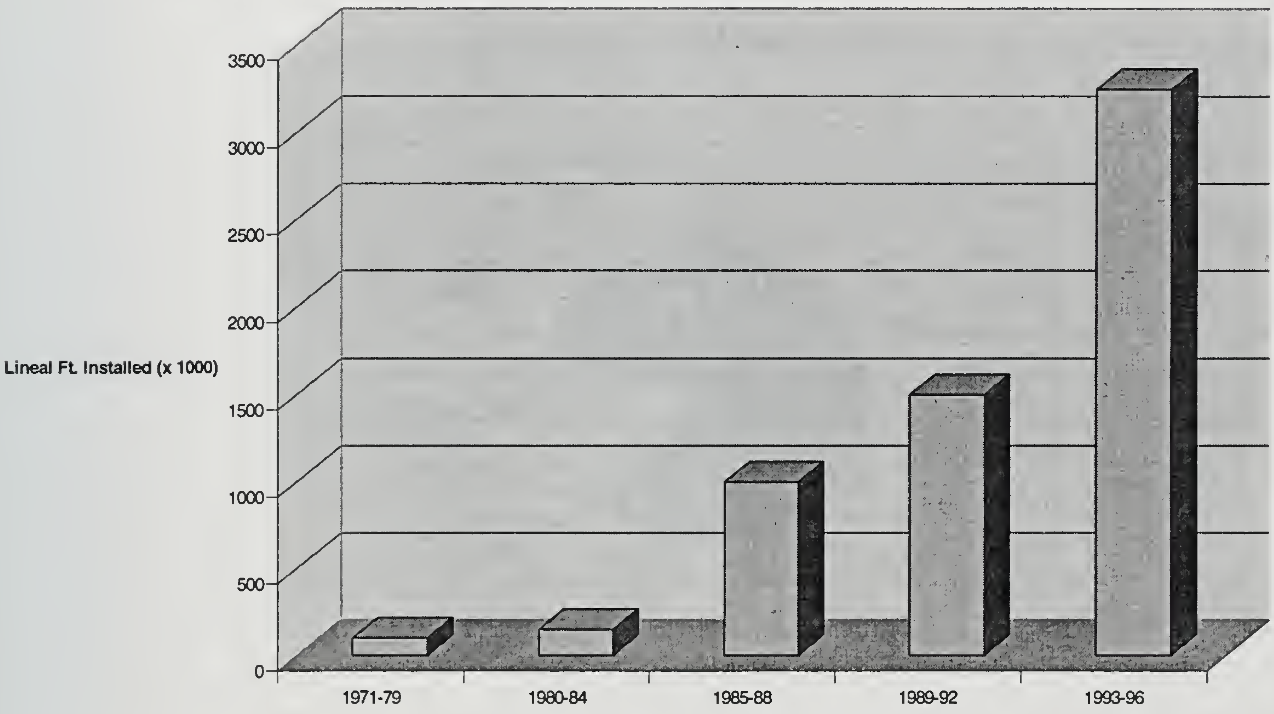
New utility installation in North America amounted to over $16 billion dollars in 1998. Since so much land has been developed, it has become harder to place new lines. It is also often necessary to install utilities in areas once considered undesireable, undevelopable or cost prohibitive. Environmental agencies now make it very difficult, if not impossible to construct utilities by open cutting under waterways and through wetlands. This being the case, it is clear that alternative methods to conventional methods (open cut, pipeline bridges) need to be promoted and enhanced. The alternative methods which have been greatly developed in the 1990's are trenchless technologies. One main trenchless technology is horizontal directional drilling (HDD). Also referred to as directional drilling, HDD is only used for the construction of new lines.

HDD is a process which is similar to vertical drilling of oil and water wells; although HDD is much more versatile. It allows for drilling to be conducted in both the vertical and horizontal direction and also allows for some steering, dependent upon subsurface conditions. There is minimal disruption to the ground surface. The bore is made at an angle and levels out at a specified depth. Once

depth has been achieved, the bore is advanced horizontally until it is redirected for exiting.

Utilities have been built by HDD under rivers, highways, railroads, airport runways, shore approaches and areas congested with buildings. This technology has seen remarkable growth in the 1990's as evidenced by Figure 1. (Gokhale, pg. 21)

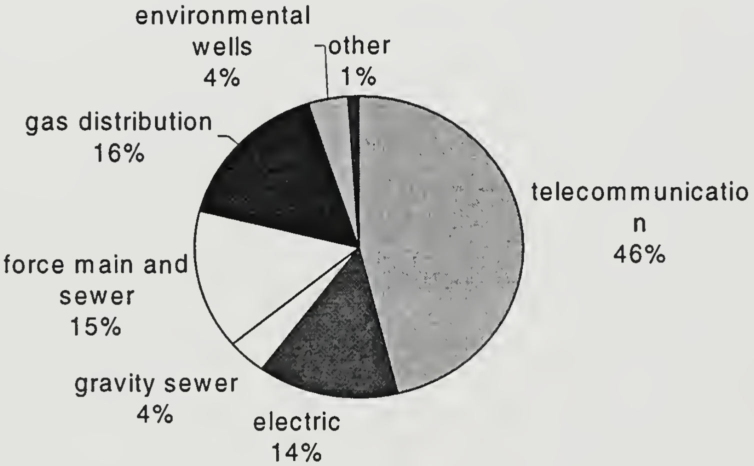
Figure 1: HDD North American Growth



Horizontal directional drilling has proven to be reliable and cost effective for numerous installations of

utilities all over the world. This will be evidenced best in the Benefits chapter of this paper. The longest crossing to date has been 6000 feet. The largest diameter pipe installation has been 48″, while the greatest depth achieved has been 200 feet. In 1998, 89% of installations were under 4″ in diameter, 10% were for installations from 4-12″, and 1% were for pipelines over 12 inches. Many different utilities can be installed using this technology. A breakdown of the installations in 1998 is seen in Figure 2.(Gokhale, pg. 22)

Figure 2: HDD Breakdown



The technology continues to revolutionize the underground utility industry. The confidence of the industry and the development of locator technology have progressed to the point where sewer lines can be installed on grade. As late

of 1995, this was not thought to be possible with this technology.

While this paper will focus specifically on the HDD industry for the installation of utilities, it is important to note that this technology is also becoming prevalent for the sampling and monitoring of suspected contaminated soils and groundwater. It offers an alternative to the traditional method of vertical drilling as it can promote sampling under roads, rivers and other obstacles.

Chapter 2: Design Information, Construction Process

2:1 Geotechnical and Design Data

Before construction can begin, it is very important to have performed a proper site survey and geotechnical analysis of the area. It is even more important to do this for directional drilling than for normal cut and cover operations since the obstructions and soil will be hidden from the driller completely. He will essentially be drilling "in the blind". A proper geotechnical analysis can ultimately save much time and money for both the contractor and the owner. Boreholes should be drilled a maximum of 300 feet apart, 25-50 feet from the centerline of the crossing to prevent drilling fluid loss during the installation, and 16-32 feet deeper than the lowest elevation proposed for the pipeline. For river crossings, boreholes should be made, at a minimum, on each side of the river. (ASCE, pg. 63) The term pipeline is used in the next few chapters. Conduit (normally high density polyethylene - HDPE) for both the electrical and telecommunications industry is installed in the same fashion as water, sewer, gas and oil pipelines.

The geotechnical report should include:

- Detailed bore logs
- Standard soil classification (gravelly sand, silty gravel, etc)
- Sieve analysis of granular materials
- Unconfined compressive strength of soil and rock samples

If rock is found, the contractors should be able to view it at a pre-bid conference. It is very important to know where rock is located, what kind it is and what compressive strength it has. Rock and soil conditions affect the size of the rig, and the types of reamers and drill bits used. In fact, if a medium size rig was specified, and significant rock was found, a large rig would then be necessary. Other soils information can be found from:

- Past and present construction sites, daily reports
- Review of glacial geology
- Local and state highway departments
- Army Corps of Engineers

The final design should include a plan view depicting soil borehole locations, proposed crossing centerline, water or obstacle limits, adjacent pipelines and

structures, topography, entry and exit locations, and pipeline right-of way. A profile view showing soil stratigraphy, borehole locations, proposed drill path, surface elevations, pipeline radius of curvature, channel bottom profile, and entry and exit angles should be included. (ASCE, pg.64) Entry angles are normally specified to be between 8-20 degrees, with 12 degrees being ideal, while exit angles are usually between 5-12 degrees with 10 degrees being ideal.

2.2 Construction Process

The construction process of HDD involves 5 steps:

1. Set up of the equipment
2. Drilling the pilot hole
3. Reaming of the hole
4. Pullback
5. Tie -in.

Set up of the equipment involves a rig side and a pipe side. The rig side contains such items as the drilling rig, slurry mixing and separation equipment, storage of bentonite, an entry point and a cuttings settlement pit. An example of a medium or large rig side layout can be seen in Figure 3.

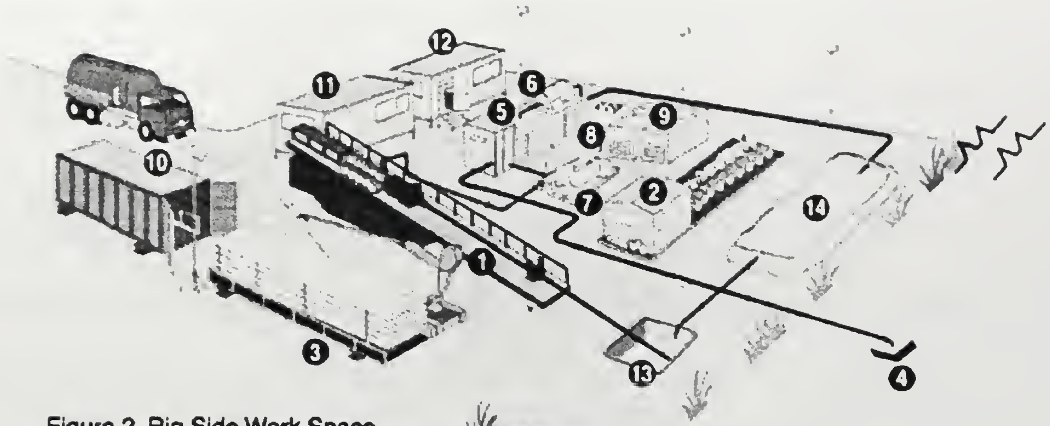


Figure 2. Rig Side Work Space

1. Rig Unit
2. Control Cab Power Unit
3. Drill Pipe
4. Water Pump
5. Slurry Mixing Tank
6. Cuttings Separation Eqpt.
7. Slurry Pump
8. Bentonite Storage
9. Power Generators
10. Spares Storage
11. Site Office
12. Site Office
13. Entry Point Slurry Containment
14. Cuttings Settlement Pit

Picture downloaded from site http://www.trenchlessdataservice.com/dirdrill/ddtecovr.htm

Rig side sizes and layouts differ for each project, depending on such things as location (urban or rural), space available, and size of the rig. Rig size depends upon the diameter and length of the pipe to be installed along with the soil conditions. Some rig side layouts can be 50 feet by 100 feet, with some larger than that. Small projects can utilize rig sides which only have a rig and equipment for the slurry and can essentially fit in the right-of-way beside a highway. Sometimes because of space available, the rig side is constructed in a linear fashion.

The pipe side contains an exit pit, pipeline rollers and a cuttings settlement pit. An example of a typical pipe side layout is shown in Figure 4. The pipe side should be

a minimum of 15 feet wide and hopefully allow for enough length for the pipeline to be fabricated in 1 continuous string. Sometimes, it is quite a luxury to have enough room to construct the new pipeline in 1 string, but contractors are leary of having the pipe bind (get stuck) in the bore if they do not.

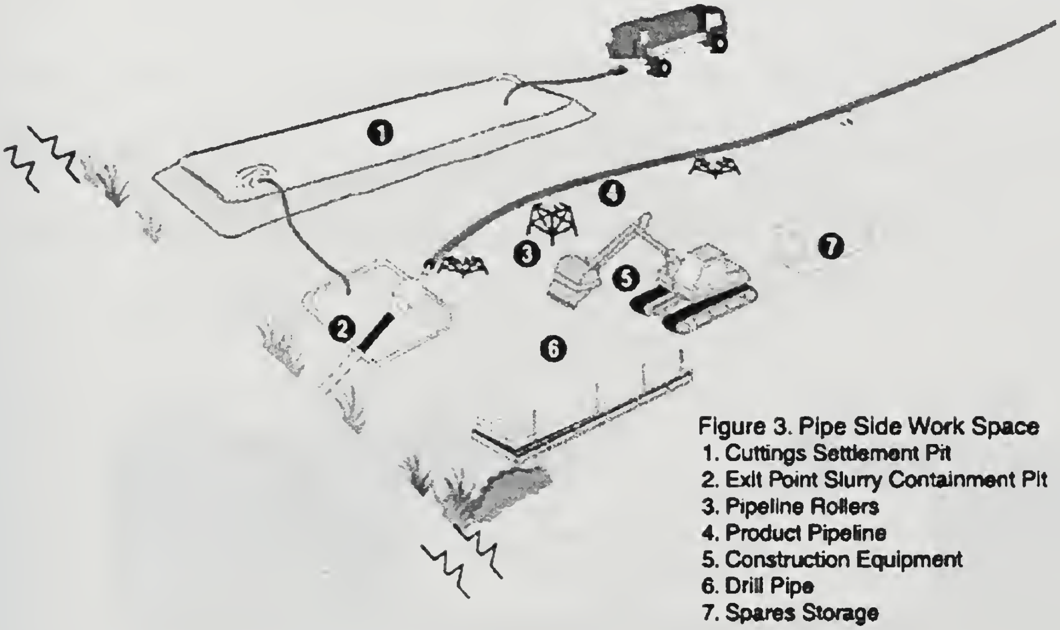


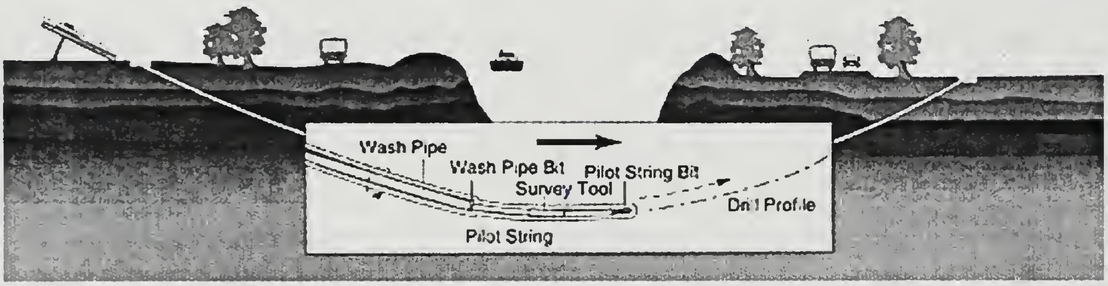
Figure 3. Pipe Side Work Space
1. Cuttings Settlement Pit
2. Exit Point Slurry Containment Pit
3. Pipeline Rollers
4. Product Pipeline
5. Construction Equipment
6. Drill Pipe
7. Spares Storage

Picture downloaded from site http://www.trenchlessdataservice.com/dirdrill/ddtecovr.htm

The drilling of the pilot hole is the most important part of the project. A general picture of this process can be seen in Figure 5. The pilot hole (4″ -12″ in diameter) is dug by thrusting and turning the drill pipe (1″ - 6″ in diameter) or wash pipe and cutting tool from the rig side to the pipe side, where the pilot string is the entire length of drill string(drill pipe or wash pipe + survey

tool + drill bit). Wash pipes are drill pipes with extra casing (steel or HDPE) for unstable soils. They provide a better ability to back the bit out of the hole, if necessary. Different bits are used for different soils. Different types of surveying tools are available to inform the driller where the head of the drill bit is located. The type of survey tool used is dependent upon depth and resources of the contractor. After the cutting tool reaches the pipe side, the bit and the bottom hole assembly (survey tool and bit) are removed, and a reamer is installed.

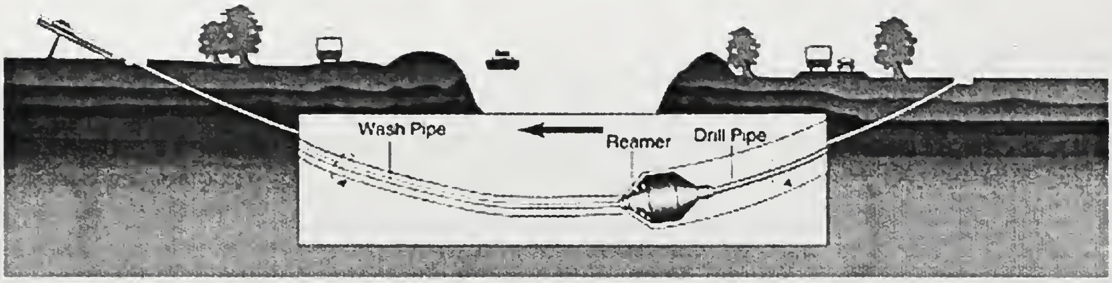
I.D.1. Pilot Hole



Picture downloaded from site http://www.trenchlessdataservice.com/dirdrill/ddtecovr.htm

The reamer is then pulled from the pipe side to the rig side(Figure 6), with pipe added at the pipe side to ensure a continuous line in the hole.

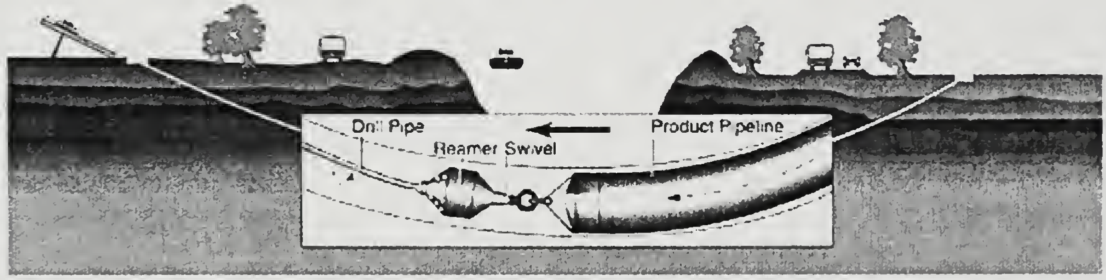
I.D.2. Preream



Picture downloaded from site http://www.trenchlessdataservice.com/dirdrill/ddtecovr.htm

The reamer's job is to enlarge the hole, and if needed, numerous reamers of gradually larger diameters are used to ensure the hole is large enough for the final pipeline. As with the cutting tool, there are different types of reamers for different soils. Once the hole is approximately 1.5 times the size of the pipe, the pipeline is ready to be pulled.(Figure 7)

I.D.3. Pullback



Picture downloaded from site http://www.trenchlessdataservice.com/dirdrill/ddtecovr.htm

To prevent the turning of the drill pipe from twisting the pipeline, a swivel is inserted between the reamer and the pipe. Swivels are not the insignificant size that a

layman would think. The larger ones are the size of a grown man and can withstand over 500,000 pounds of force.

Now that the general process has been described, the different major components will be described in more detail.

Chapter 3: Major Components

3.1 Drill Rig

The drilling rig is used for all phases - pilot hole, reaming and pullback. Drilling rigs are also referred to as boring machines and drills. Important characteristics to be aware of for the drilling rig are forward thrust, pullback and rotational torque. Thrust and pullback rate the size of the rig. Rigs are generally classified as large, mid size (medium), and small. Mid sized rigs generally complete projects in the 500 ft - 2000 ft range and pipelines from 4″ to 24″ in diameter. A comparison for small, medium and large rigs is as follows:

Table 1: Rig Characteristics

Rig Size	Push/Pull(lbs)	Pump Rate(gpm of slurry)
Small	to 25,000	40 and less
Medium	25,000 - 100,000	40 - 200
Large	100,000 and more	150 and up

A sampling of different sizes of rigs and their specifications, can be found in the Appendix.

Another way to classify drilling rigs is whether it is self contained or remote. Self contained units have the power unit, drill pipe and rack all on board, whereas

remote units have a power unit attached permanently to a truck bed. Self contained rigs have the benefit of reduced setup time, and remote units have the advantage of being more adaptable to urban areas since the overall components can be separated.

3.2 Drill Pipe

The drill pipe (also referred to as drill stem, drill rod) which is used for the bore is dependent on the size of rig. Typical sizes for the drill pipe are an outside diameter between 1 and 6 inches and a total length of between 6 and 30 feet. The pipe has to withstand severe stresses related to rotational torque, pushing, pulling, and bending. The pipe is also hollow, allowing the drillers mud to be pumped through to the head for cutting of the soil. The most common type of pipe is a one-piece forged steel pipe with machined threads. An example of drill pipe can be found in the Appendix. Generally speaking, larger diameter drill pipe cannot bend safely in a short distance, so small bores cannot be completed with large drill pipe, while smaller diameter drill pipe is more flexible and better suited for short bores. In general, the planned radius or curvature of the bore should be at least 100 times the diameter of the drill pipe. (Trenchless Data

Service) As the pipe progresses, additional drill pipes are added. One key maintenance item for the drill pipe is proper cleaning of soil particles and dirt from the threads of the drill pipe. This is often not done, which of course, causes problems.

3.3 Slurry

The slurry is mixed in a mixing tank by a "mud man", and then flexible hoses carry the slurry to the rig, where slurry is pumped through the drill pipe. The slurry (drilling fluid, drillers mud) provides many necessary functions in the pilot hole process. It

- Establishes and maintains hole integrity
- Provides cooling for the drill head
- Lubricates the drill string
- Suspends cuttings in the hole and helps to float them out
- Retains drilling fluid in the hole without having it dissipate into the surrounding formation
- Provides hydraulic horsepower for mud motors in hard soils

The process of fluid assisted drilling or jetting accomplishes the above functions by water alone (very

seldom), bentonite slurry (bentonite with water), or a mixture of bentonite and polymer. In real sticky clays, a biodegradable, nonfoaming detergent (surfactant) is added. The detergent leaves a thin film on the drill stem, keeping the material from sticking.

Bentonite is non-hazardous aluminum silicate clay, with Wyoming bentonite being the premium quality. Bentonite should be used in most soils, definitely with coarse soils - sands and gravels; where polymers are best suited for finer soils – clays and shales. It is usually best to use a combination of bentonite and polymers in the bore since there is invariably some coarse and some fines. When added to water, bentonite breaks up into microscopic platelets and has a shingling effect on the hole, preventing fluid from escaping and helping to maintain hole integrity. Typically, 15-25 pounds of bentonite are used per 100 gallons of water.

Polymers are used when clay is present as the polymers wrap themselves around the clay cuttings, limiting the clay's intake of water and reducing the clay's ability to swell. Normally, 1 quart of polymer is used per 100 gallons.

The water source is also very important. Salt water is not desirable due to its abrasive nature and poor mixing

characteristics when combined with bentonite. Since so much water is used in the HDD process, impacts to the source should be considered.

3.4 Slurry Recycling/Mixing Systems

These systems should be a vital part of any HDD (large or small) operation as when the job is going smoothly, there should be a return of slurry from the entry or exit pit. A recycling system cleans the returned slurry, allowing the liquid phase to be reused and discards the cuttings. A highly efficient system can clean the returned fluid down to less than 1% sand. (Clayton, pg. 46) There are many benefits to using a recycling or cleaning system. These include:

- Cleaner, safer drilling location
- Reduced disposal costs
- Reduced drilling fluid costs (Slurry costs an average of 10 cents/gallon)
- Reduced water hauling
- Environmental considerations
- Reduced overall project costs

Many types of these systems are available. Some of these systems are listed in the Appendix. Four main elements comprise the system - slurry pump, fluids tank, shaker and mud cleaner. The slurry pump routes the slurry from the entry or exit pit to the recycling system for processing. The fluids tank doubles as a mixing tank with the cleaning equipment on the top of the tank. The shaker is the first part of the cleaning process where large cuttings are removed. The slurry and remaining smaller cuttings are redirected to a mud cleaner, which has an additional shaker with desander/desilter cones mounted over the top. The slurry is then discharged into the mixing tank portion of the fluids tank. These units require a dedicated crew member or "mud man".

3.5 Survey Systems

Two basic forms of survey systems exist. These are the walkover system and the wireline steering tool system. The most recent development - wire less steering - will be utilized in 1999 for the first time. Wire less steering eliminates the need for a person to physically walk over the line to determine either depth or alignment.

The walkover system is exactly what the name implies. A person with a receiver has to walk over the position of

the drill head, where the survey instrument or transmitter (sonde) is located. The receiver processes the signal from the transmitter and calculates the pitch, roll and depth. Transmitter specifications are contained in the Appendix. These 3 pieces of information are then conveyed to the driller or sent to a remote display at the drill rack, where the driller can then make appropriate adjustments, if necessary.

Readings should be taken no more than 30 feet apart. Pitch indicates whether the drill head is level, pointing up or pointing down. Roll tells the rotational position of the drill head with position of the drill head calculated according to time on a clock. Three general classes of transmitters are used for the walkover system - these are short range (depth to 15 ft), medium range (depth to 40 ft) and long range (depths to 70 ft). These transmitters are battery powered and are only good to 70 feet. Past this depth, it is necessary to use the wireline steering system.

The wireline steering tool system has the advantage of increased depth as the transmitter is connected to a surface computer that gives continuous readouts of pitch and roll to the operator at the drill rig. This is done as a wireline is connected from the transmitter to the surface computer by running it inside of the drill pipe. The

similarity to the walkover system is that a locator is still needed to determine the depth. The wireline steering is less easily influenced by buried trash and metal in the ground, but it is also more expensive than the walkover system.

3.6 Drill Bits

The selection of the proper drill bit depends upon the soil which will be encountered. The drill bit is part of the tooling assembly or bottom hole assembly. The bottom hole assembly also houses the transmitter. The entire bottom hole assembly threads into the drill pipe. Drill bits come in a variety of shapes and sizes.

In soft soils, a bit referred to as a steering shoe is used. It is actually not a bit in the conventional sense as it relies on the jetting action of the slurry to accomplish the cutting. Based upon which direction the shoe is inclined is what position it will head. The 12 o'clock position (fluid sent off the angled shoe) allows the head to go up. Down, left and right capabilities are provided by having the shoe and jetting at 6, 9 or 3 o'clock positions. To make course corrections, it is necessary to stop rotating, rotate the jet to a new course,

and thrust forward. Once the new course has been established, rotation can resume.

For medium (harder packed coarse and fine) and hard soils (rock), a bent sub is used directly before the bit. The bent sub provides steerability and directional ability just as the shoe did for the soft soils. Different types of bits for medium hard soils are milled tooth bits, diamond bits, and tricone roller bits. Diamond bits are best used in homogenous soils, are very expensive ($4000) and are destroyed by cobbles. Tricone roller bits and milltooth bits tend to work best and are the most popular. Hard soils(rock formations) are drilled with tricone roller bits with tungsten carbide inserts. These bits are very rugged and do well in rock formations. Their cost is anywhere between $3,000 and $10,000. Mud motors must be used to power the above listed bits when drilling medium to hard formations. These motors are used to rotate the cutting head and are directly in front of the bit. The motor is powered by the flow of drilling fluid (minimum of 40 gpm)which is forced through it. This automatically means that at least a mid size rig should be used to properly run the mud motor.

Thankfully, in the last couple years, bits have been produced by companies that are "all soils bits". These

bits can usually accomplish a complete bore by themselves, without being pulled out - a huge benefit. The "all soils bits" only nemesis is medium to hard rock, or in other words, rock above 6000 psi. The great benefit to "all soils bits" is that they don't require a mud motor and thus can be used with small sized rigs. These bits evolved from the steering shoe design. Unlike the traditional steering shoe, these bits are designed with more secure transmitter housings and rock point tips.

3.7 Reamers

The reamer is used to enlarge the pilot hole so that the hole is large enough to accommodate the new line. For smaller lines, the pilot hole is large enough for the pipeline. For larger lines, the process has to be repeated with larger and larger reamers until the bore is roughly 1.5 times the size of the pipe. The hole needs to be this large to allow for the bend radius of the pipe,for movement of drilling fluids and spoils, and to limit gouging of the pipe by rocks in the soil. For example, during construction which allowed the Gloucester sewer force main to be built under the York River in Norfolk in 1992, 6 reaming passes were needed. The soils encountered were

sand and silt and this number of passes were necessary to provide a firm and stable base for pullback.

Different soils require different types of reamers. Generally speaking, the blade reamer performs best in soft soils; the barrel reamer performs well in medium soils and a rock reamer is used in rock formations. A rock reamer with tungsten carbide inserts is used in very hard rock. Some types of reamers can be seen in the Appendix. Many contractors manufacture their own reamers; other standard types of reamers are the:

- Spiral reamer - used for obstacles such as rocks, gravel, tree roots, not very good in dry clay or compacted sand
- Wing cutter - works well in dry clay and compacted sand
- Helical - does not hold up well under rocky or abrasive conditions
- Fluted reamer - used in sand and hard packed sand with rock, balls up in sticky clay conditions

3.8 Pipeline Materials

The pipe materials need to withstand some severe bending and pulling stresses. The stresses result from the

pulling into the hole, bending when subjected to the curvature of the bore, overburden pressure in the hole, and working pressure of the line. For this reason, brittle materials cannot be used. The two main materials which are used are steel and high-density polyethylene (HDPE). In some cases, ductile iron is also used. Steel pipe is joined by welding, whereas HDPE pipe sections are commonly connected with couplings that lock tightly with the precision machined grooves on the pipe. Steel is preferred because of its greater tensile strength and ability to resist deformation.

While it is always necessary to calculate the actual forces to determine the thickness of the pipe, the following information can be used as a general guide:

Table 2: Recommended Steel Pipe Thickness

Steel pipe size (D - diameter)	wall thickness (t)
6″ and less	0.250
6 - 12″	0.375
12 - 30″	0.500
30″ and more	D/t <= 60

A general guide for HDPE pipe is that D/t <= 11.

(Trenchless Data Service)

The main reason to be concerned about thickness is deformation. Since HDD operations can also be buried quite deep, and the anticipated lifespan is a minimum of 50 years, thickness also helps the corrosion part of the equation, at least for steel pipe. For steel pipe, it is commonly specified that a 20 mil thickness of liquid epoxy be applied in order to reduce friction during pullback and minimize corrosion, particulary at the welds. When steel and HDPE pipe is installed in rock formations, it is common to apply a epoxy based polymer to the outside of the pipe to reduce gouging of the pipe.

Chapter 4: Benefits of Horizontal Directional Drilling

The increased use of Horizontal Directional Drilling in the 1990's should be no mystery. Numerous projects and success stories point to the great advantage that HDD provides over conventional techniques, particulary in built up areas, rivers and wetlands. The benefits provided can be grouped into 5 main areas:

1. Construction cost savings
2. Friend to the environment
3. Feasible option for congested areas
4. Social benefits
5. Time

In discussion of the above 5 areas, it will be clear that HDD technology offers clear advantages in many varying cases of location, different utilities and sizes of installed pipe, and varying pipeline lengths. Time will not be given its own section, rather it will be woven into the other 4 sections. Actual construction time can usually be accomplished significantly quicker than conventional methods. It should also be noted that safety is much better on a job with horizontal directional drilling as there is no trench. There have been too many accidents

which occur on open cut construction sites because of cave-ins due to faulty shoring or lack of shoring.

4.1 Construction Costs

In December of 1997, the Water Distribution Division of Wichita, Kansas purchased its own directional drilling rig. Comparing costs for open trenching with the cost of purchasing a directional drilling rig convinced city officials that HDD would be less expensive over the life of the boring machine. They purchased a Ditch Witch, Model JT1720, which is capable of 17,000 pounds of thrust and pullback, or in other words, a small rig for $120,000. The original estimates showed projected yearly savings of $25,000 based upon 30 four inch and larger domestic and fire service installations each year.

In actual practice during the first year of service, the drill was instead used for the installation of five 1″ domestic service lines, 2,000 feet of 8″ water main and 20,000 feet of 1.25″ and 4″ fiberoptic conduit. Savings, after deducting $8,000 amortization cost, were $29,510 for the first year. For depreciation purposes, the rig is assumed to have a 15 year lifespan. The following data

provided by Mr. Joe Botinelly of the Wichita Water and Sewer Department provides justification for the savings.

Table 3: Wichita, Kansas Cost Data

	water mains	**service lines**	**fiberoptic**
feet installed	2,000	250	20,000
HDD installation (actual)	$17,950	$1,900	$60,800
trenching installation (estimate)	$22,000	$2,800	$56,000
paving replacement saved (yds)	53	50	0
paving replacement cost saved	$4,120	$3,900	0
landscape replacement saved(yds)	1320	0	13,330
landscape replacement cost saved	$2,640	0	$26,700
net savings	$10,810	$4,800	$21,900

As is seen by the above information, the savings is not always directly attributable to the actual installation, but to the savings related to paving and restoration of the landscape.

On July 10, 1997, the Massachusetts Legislature enacted a bill declaring a public health emergency in Braintree and Weymouth as sewage overflows had been routinely occurring in moderately wet weather. These overflows had been causing wastewater discharges to occur from manholes in streets in Weymouth and at Smith Beach in Braintree. Both areas are in the greater Boston area and a part of the Massachusetts Water Resources Authority (MWRA). The problem resulted from the fact that the 42" interceptor sewer was no longer capable of supporting the flow from the

tributaries because of the growth in the community. The solution was to provide a redundant 42″ line to backup the 54 year old 42″ cast iron line. The redundant line would span over 2000 feet and be constructed under Mill Cove in the Weymouth Fore River between the two congested urban areas. Two options were investigated - open cut and HDD. The open cut option was estimated to cost $10.9 million, with an estimated duration for design and construction of 24 months. The HDD option was estimated at $3.9 million with a duration of 17 months. The HDD option was selected based on these figures. Ultimately, this work was awarded for $2.67 million, and actual construction was completed in 3 months, with the HDD installation of a 42″ HDPE pipe to backup the existing. Whereas the Wichita example showed that HDD was beneficial in an urban area for small diameter installations, this example undoubtedly shows cost and time benefits for larger installations. The environmental and social impacts of this project will be discussed in the appropriate sections.

Horizontal directional drilling is also very popular in Europe. Costs for small diameter installations of pressure pipe and cable duct in Europe in 1998 are listed in the following table.

Table 4:1998 Europe HDD installation costs(Thomson, pg. 25)

diameter (in.)	open -cut ($/ft)	HDD ($/ft)
2.5	$23.40	$12.30
3.5	$25.50	$13.50
5	$27.60	$16.50
7	$34.50	$22.50

While the costs for the European installation are higher than the Wichita data, the above information takes into account all known HDD installations throughout 1998. It certainly shows that the application of HDD is much more cost effective than open cutting.

In the introduction of this paper, it was shown that HDD has recently become a more popular use of technology for utility construction in North America. A cost comparison for the years 1988 and 1998 for pressure pipe and cable duct installation reveals some interesting information.

Table 5: North America HDD Cost Data (Thomson, pg.25)

diameter (in.)	HDD ($/ft) -1988	HDD ($/ft) - 1998
2.5	$15.00	$10.50
3.5	$17.40	$12.60
5	$19.50	$15
7	$25.50	$21.60

As can be seen from the above data, the cost to install pipelines using HDD in North America has actually

decreased in the last 10 years. This is due to greater competition, improved equipment, and better training programs. It is important to note that in the same span of 10 years, *Engineering News Record* indicates that the construction cost index has increased 30%.

A cost comparison for open cut and directional drilling can be summarized into the following factors.

Table 6: Summary of Cost Factors for Open Cut and Directional Drilling Operations (Thomson, pg. 26)

Factor	Open-Cut	Directional Drilling
Depth	Major	Minor
Diameter > 6″	Moderate	Major
Soil Conditions	Major	Moderate
Obstructions	Minor	Moderate
Water Table	Major	Moderate
Existing Utilities	Major	Moderate
Re-Instatement (Soil, Pavement)	Major	Minor
Traffic	Major	Minor
Design	Moderate	Major

Ultimately, savings can be attributed to lack of requirement for shoring, trenching, and dewatering, the

lack of replacement of soil, pavement and landscape and the overall speed in which HDD can accomplished. A standard 3-5 man crew can easily accomplish 350 feet of work in soils not containing large amounts of rock.

4.2 Environmental Benefits

There are numerous environmental benefits to using HDD. In fact, for some parts of the United States, this technology has become the only acceptable solution for crossing under waterways and wetlands. Since HDD provides for limited disturbance of land and water, it is indeed an ideal technology as there is no excavation except for the entry and exit pit.

The numerous benefits provided are:

- No disturbance to wetland and wildlife habitat
- Minimal water and land pollution
- Minimal impact, if any, to steep slopes and sediment
- Decreased need to dispose of unsuitable material
- Minimal impact to historical and cultural sites

A few examples will be able to illustrate these points.

In 1992, the Hampton Roads Sanitation District (HRSD) was extending its Gloucester interceptor force sewer main by 20 miles from historic Yorktown to the Gloucester Courthouse. This new pipeline extension would provide regional wastewater service to an area previously only served by septic tanks. The challenging part of the project would be the design and construction of 3500 feet of 30″ steel pipe under the York River. HDD was chosen as the method of construction and was ultimately successful.

The environmental and cultural benefits enjoyed from using this method of construction were numerous. The active shellfish beds and wetlands were left undisturbed. There was no need to get involved with the underground soil and groundwater contamination since a minimum of 30 feet of cover below the river bottom was specified, and HDD could achieve that without a problem. On the historic side, the application of trenchless technology was able to leave the remains of Lord Cornwallis' fleet intact. He had scuttled his fleet in that area of the York River in 1781. Additionally, there was a lack of suitable staging areas because of mainly National Park Service land. Fortunately, a small parcel was available for the rig side. Since the rig side setup can be flexible, the space was sufficient.

The town of Sarasota, Florida was looking to expand its urban reclaimed water reuse system to allow for more flexibility in its effluent disposal options. In order to complete the southern loop would require an 18 inch pipeline crossing of environmentally sensitive Hudson Bayou, which is a tributary of Sarasota Bay. Sarasota Bay was chosen as a National Estuary Program waterbody in 1988 by the U.S. Environmental Protection agency. (Veith, pg. 95) In the preliminary design, 5 pipeline crossings were considered with the following criteria in mind: constructability, permitability, aesthetics, estimated cost of construction, estimated future maintenance and replacement costs, and navigability of waterway during construction. The 5 options which were investigated were directional drilling, jack and bore, a new pipe bridge, conventional open cut, and use of the existing bridge.

Directional drilling was ultimately chosen because this option allowed the construction of the 18″ pipe under the bottom of the Bayou. This would allow the aquatic wildlife to include the endangered manatees, the channel bottom and navigation to remain unaffected. While the Army Corps of Engineers required a general permit, the Florida Department of Environmental Protection (FDEP) did not require a permit. This was very different from open

cutting as it seemed doubtful that FDEP would permit that type of construction. The new pipe bridge would require removal of dense vegetation, mangroves and other vegetation along each bank and would require extensive permitting. The jack and bore method would require 20 foot depths for sending and receiving pits, which made extensive dewatering, trenching and shoring necessary. It was determined that the existing Osprey Avenue Bridge already had reached its limit with carrying utilities as it had 5 different utilities attached to it.

Construction of the pipeline was started and completed in the Fall of 1996 in 10 construction days. No way would this amount of time be sufficient to have performed the other methods discussed. The successful completion of the project and proof that it had not affected the manatee make HDD the best option for pipeline work in aquatic areas.

The environmental benefit of the new 42" sewer interceptor which was completed in south Boston and discussed in the cost section needs to be addressed. The benefits of it being constructed under the waterbody of Mill Cove should be clear because of the prior 2 examples. The speed in which HDD can be accomplished provided another environmental benefit. When the Massachusetts Legislature enacted that bill on July 10, 1997, it required that the

dual interceptor be in place by January 6, 1998. On July 10, the project was in the design phase. The design was fast tracked, and construction started in late August. The new line was tied into the existing interceptor system on December 17, 1997, which was 3 weeks ahead of schedule. The open cut option would have taken at least 7 more months of work. The relief line provided immediate improvements to water quality in the Weymouth Fore River. Hydraulic modeling performed during the design indicated that there would be 78% reduction in overflow volume for any particular year. (Spearin, pg.38)

4.3 Feasible Option for Congested Areas

Modern society has built its infrastructure and urban environment to the point where it is highly difficult to construct new utilities in these developed areas. This section will give a few examples of projects which were completed by HDD, not necessarily because of cost, environmental or social reasons, but because there was no other option which was really possible.

In late 1998 and 1999, the city of Des Moines, Iowa used directional drilling for the installation of numerous water mains. The job was the first in Iowa where directional drilling was used for a project of this type

that included major urban construction. In all, 11 bores were completed, with 6 between 500 and 600 feet, and 5 between 100 and 150 feet. The average depth for the mains, which ranged in size from 8″ to 12″, was 10 feet. It is becoming more popular to use HDD to install force water mains.

Directional drilling was selected for the project because of numerous reasons. These include:

- Many buried utilities in the area, including fiberoptic cable - HDD is capable of going lower than them without interruption
- Avoid interrupting traffic on 2 of the busiest streets in Des Moines
- Eliminate damage to retaining walls and other structures on the right-of-way

As can be seen, it would have been highly complex to undertake the route of open cutting, which would have been very difficult in this area.

Another example is an 18″ natural gas pipeline crossing of the Cape Cod Canal. The Canal Electric Company, located on Cape Cod, decided in 1992 to change from an oil fired boiler to the burning of natural gas. To do so meant that a 4.5 mile pipeline would have to be built

from Algonquin Gas Transmission Company's existing supply main. This would require a crossing of the Cape Cod Canal.

Original options included using 1 of the 2 highway bridges, constructing an aerial crossing, and direct underwater installation. The Army Corps of Engineers evaluated the options since it is in charge of the Canal. It was determined that each of highway bridges was already carrying its capacity, and no additional loads would be allowed. An aerial crossing was eliminated since the line would have to be 135 feet above mean high water (to allow for passage of ships), and the design was too complex. Shallow underwater installation was too risky because of maintenance dredging of the canal. In the end, the only possible method of construction was HDD, which could be constructed below the dredge and scour line of the canal. The 18" steel pipeline crossing was completed in 5 days in July, 1995 and was 1454 feet long and 20 feet below the dredge line.

4.4 Social Benefits

Social benefits are a definite advantage of HDD. With the relatively minor obstruction and digging required with the entry and exit pits, there is usually no disruption to

roadways, waterways, public and private property. These types of benefits are definitely a soft truth rather than a hard truth like cost savings. Nevertheless, the social benefits alone could be reason to use HDD.

Many references can be drawn from previously cited examples. In Wichita, Kansas and Des Moines, Iowa, there was great social benefit. It is clearly better to not have to look at a torn up landscape due to open cutting. A tattered landscape can detract from tourism. A torn up road in front of a retail store or business can limit sales. The traffic benefits of no delays, less accidents and no construction zone are obvious. A paper entitled "User Costs at the Work Zone" by Dr. Fazil Najafi showed that a 6.8% increase in accident rates was observed during construction at 79 work sites. Invariably, after a road or pavement surface is cut and repaved, it settles, causing a rut for motorists. In the Boston interceptor project, it is clear that HDD, because of its shorter construction timeframe than open cutting, allowed for a quicker end to the potential health problem caused by wastewater overflowing from manholes during storm events. In the HRSD Gloucester example, open cutting would create a difficult situation for the US Navy, which uses the York River as ships go into and out of the Yorktown area. Navigation was

also a concern for the US Coast Guard when other options other than HDD were discussed for crossing the Hudson Bayou in Sarasota, Florida. It is clear that directional drilling reduces the social costs when it is used.

Chapter 5: Challenges and Risks

While the many benefits of horizontal directional drilling were just explained, there is indeed many challenges associated with this work. There is the concern that the soil information and the existing utilities are indicated in the field and on the drawings completely and correctly. This is one reason that contracts for this work should be written so that contractor and owner share the risk. In fact, some projects are written in 2 contracts – one for the pilot hole and then one for the remainder of the work. Subsurface conditions can be a concern, particulary if there is cobbles, flowing groundwater, or a gravel bed. Proper training is key as locating and mastering control of the drill rig and the drill bit through different soils takes time to learn. The proper use and knowledge of drilling fluids can also be a challenge. Binding of the drill pipe and bit or reamer in the hole can occur. Deformation of the pipeline can still occur when pulled into the hole if standards are not followed. Deformation is not a common occurrence for steel pipe anymore, but it can be for HDPE pipe, particulary when the contractor ignores the diameter/thickness requirements. Besides concern for their equipment, these ideas were the main concerns indicated by a poll of 117 directional

drilling contractors in late 1998. The results were published in the February, 1999 issue of Directional Drilling magazine. The challenges and risks and the actions taken to counteract them will now be examined in more detail.

5.1 Soil Information and Existing Utilities

While it seems clear that planning, design and geotechnical evaluation of a HDD project (described in Chapter 2) are performed better than for conventional construction, there can still be mistakes and unknowns. For example, numerous HDD projects caused utility damages to utilities which were improperly marked. Drill cores, which are the typical analysis of the soil, are narrow column samples and cannot always provide reliable assumptions of the lateral continuity of the soil throughout the length of the drill path. So, if it is unclear where all of the utilities are, and the typical geotechnical analysis is not enough, the answer could be to use a method such as Ground Penetrating Radar(GPR).

Ground Penetrating Radar is the most common method of analyzing soil from the ground surface. GPR is capable of detecting changes between sands, silts, clays and gravels, identifying voids in the grounds, and the identification of

utilities. GPR involves the transmission of radio waves into the ground and the reception of reflected energy back to the surface. In the field, both transmitter and receiver are pulled over the surface and the reflected energy from underground objects is continuously recorded. This continuous recording enables the profile of the subsurface to be seen. The radar wave reflections are a result of the different bulk electrical properties of the soil. The main properties which cause the reflections are soil grain size, compaction and water content. GPR can be effective to 150 feet. GPR has difficulty with thick clay soils as they tend to absorb the energy and not return it. GPR and other methods (EM induction, magnetics) are located on the ground, which causes problems because of the absorptive properties of some soil. As a result, current efforts and research are being accomplished to mount sensors on the drill bit, which will transmit information to the surface.

5.2 Subsurface Conditions

The main subsurface conditions which can inhibit a HDD project are flowing groundwater, gravel beds and cobbles. Flowing groundwater has the ability to ruin the bore. Gravel beds cause the slurry to be lost to the existing soil structure rather than creating a mud cake and

providing borehole stability. If the bore cannot be constructed in a fashion to limit these 2 items, it is possible that HDD would not be used.

Cobbles present an interesting dilemma. Drilling though them has been likened to trying to ram a fist through a bucket of golf balls. If the drill head is forced, the drill bit and the bottom hole assembly can be lost. It is highly difficult to maintain a course when the drill bit cannot find a solid surface in which to bite into. According to the United Soil Classification System (USCS), cobbles are rocks which are from 3″ to 12″ in size.

For example, the fear of hitting cobbles on the 18″ gas pipeline crossing of the Cape Cod Canal prohibited the Canal Electric Company and Algonquin Gas from having a long term contract until the HDD portion of the pipeline was completed. Fortunately, because of prior planning, cobbles were not encountered, and the project was completed.

Travis Wilde of MasTec, a directional drilling firm located in Miami, has said that he has had success with drilling in cobbles. On a recent project in Wyoming, he said,″ Rather than try to force it, which would send the head off in a direction we didn't want it to go, we would use a slow rotation with low thrust pressure to feel the lie of the rocks downhole. Depending on the situation, you

could drill through it or deflect and correct, thus enabling us to gradually bore through the cobbles." (Oakes, pg.21) So, while cobbles are a definite challenge, some contractors have completed jobs with them in the bore path.

5.3 Training

Companies are constantly concerned whether their personnel are qualified and trained properly. Operating a drill rig is not as simple as operating other construction equipment. It takes a lot of experience to know how much push and torque to use with various drill bits in different soils. Since the transmitter is located behind the drill bit and the bent sub, the driller must be aware of the position of the drill head in relation to the transmitter when he gets the pitch and roll information since it is the drill bit location he is concerned with. The driller also needs to be versed in some mathematics since in most river crossings and busy highway crossings, a receiver will not be used to determine depth with the wireline. He will be required to calculate the depth based upon the number of feet of drill rod used and the pitch of the transmitter. He should also be versed in basic hydraulics, basic soil mechanics and also understand drilling fluid flow. For many years, there was not a comprehensive training course

available. On-the-job training and 2-3 day seminars were the norm. There is no requirement for an operator of a drill rig to have a license to operate it.

To account for this lack of comprehensive training, the Trenchless Technology Center (TTC) and Division of Continuing Education at Missouri Western State College offered the first comprehensive HDD certification and training course (80 hours) in the United States in August, 1998. The course focused on the needs of the drilling operators and was based in the classroom and in the field. Classroom work included many topics, such as job safety, basic mathematics, hydraulics, pumps and motors, pipe and bore locating, wireline navigation, pipe fusion, soil mechanics, surveying, pipe stresses, job drawings, job management, planning, supervision and control, rig maintenance, electronics, tool selection, mud mixing, site selection, and rig set-up. In the field training consisted of installing 1500 feet of 2″ HDPE pipe. After 300 hours of documented practical work in actual job conditions under the supervision of a HDD operator, the training certificate earned at the school is replaced with an HDD operator license. The school has been a success and is attempting to make the operator license industry practice.

5.4 Drilling Fluids

Much has been learned about drilling fluids over time. In the early days, contractors tried to get away with a minimal amount of slurry in order to reduce costs. Over time, it has been proven that slurry needs to be flowing at either the entry or exit hole, and that a minimum amount of slurry is needed to ensure smooth operation within the bore. When not enough slurry is used, a condition called hydralock can result where slurry is not flowing, and the drill pipe or reamer locks up in the bore. Another condition called frac-out can occur when the natural fissures in the soil allow for the slurry to return to the surface. This will happen more often in fractured rock structures. A common misconception might be that drilling fluids pose an environmental problem, but in actuality, they do not.

The components of drilling fluid all pose no risk to the environment. Bentonite poses no risk to the environment. During the pullback of a 12″ gas pipeline by Baltimore Gas and Electric in the Summer of 1997,a frac-out occurred under the wetland which they were pulling under. While there was initial panic and the job was temporarily shut down, it turned out that there was no problem. According to Dr. Eileen McLellan, the Director of

Environmental Studies from the University of Maryland stated," Bentonite is no threat to the environment. In fact, the EPA does not even consider it as a hazardous material for drilling operations." (Agnes, pg. 31) Surprisingly enough, the polymers which are used are also no threat to the environment. The most common polymers which are used - guar gum and xanthum gum - are both common ingredients in ice cream.

While the ingredients in the slurry are not hazardous, it is required that the spoils and slurry are accounted for and not allowed to flow unimpeded on and off the jobsite. Sedimentation control is required on projects, and while bentonite does not pose a risk on river crossings, some studies have shown that introducing suspended solids into clearwater streams has a negative impact on the ecosystem. The best way to account for slurry is by use of a recycling system. In urban areas, pump trucks are sometimes used. Used slurry is usually disposed of by land farming (distributed over open area and tilled under). Spoils which are the result of recycling are disposed of as dry spoils.

The problem of frac-out has been mentioned. Frac-out is not a common occurrence, but it can happen without warning. The inadvertant fluid return is usually no more

than an annoyance to an urban area, river crossing or wetland, such as the project by Baltimore Gas and Electric; although, on rare occasions, frac-outs have washed out embankments and buckled streets. A frac -out would also cause a suspended solids problem if it occurred under a clearwater stream. While frac-outs occur naturally most of the time, they can be the result of hydralock.

Hydralock occurs when there is not a flowable slurry. This occurs because the cuttings are not being properly carried away and bind the bore. This causes pressure to build up and the drill pipe to become locked in place. The pipe does not move until the slurry finds an escape route. It can do that by causing a frac-out or by simply entering the surrounding soil without harming the surface. If the pressure does not subside on its own, a burp hole must be dug to relieve the fluid. This phenomenon of hydralock can occur in any phase of the operation - pilot hole, ream, pullback, and it is the result of not using enough drilling fluid. It has been found that a flowable slurry requires a minimum of 50/50 ratio of drilling fluid to solids.

5.5 Binding of Drill Pipe and Bit

There are times when the drill pipe can become stuck in the bore. This can occur in any phase of the operation.

Numerous ways to unlodge the drill pipe have been performed. Some examples of this will be given.

During the aforementioned installation of the 12″ gas pipeline by Baltimore Gas & Electric in the Summer of 1997,the reamer which was used became stuck. This occurred after the 6″ diameter pilot bore had gone smoothly. The 24″ reamer became stuck 200 feet downhole and 20 feet deep. To remove the reamer and drill string, the direction was reversed, and the reamer came out. A new reamer of the same size was attached, and it again became stuck in the dense black clay. Once again, the direction was reversed, but the reamer was stuck this time. Since the reamer was outside the wetland limits, it was decided to dig up the reamer and proceed with a smaller reamer. This strategy worked.

A similar problem occurred when crossing the Hudson Bayou in Sarasota, Florida. According to the boring logs for this project, a layer of rock was present at 7-12 feet below sea level. This covered a layer of clay, which would be the medium in which the pipe would ultimately reside in, under the Bayou. The 6″ pilot bore commenced from the rig area (small sized rig) on the south side, penetrated the rock layer and bored under the Bayou with relative ease. A real problem occurred when the bore tried to penetrate the

rock layer on the north side. The rock layer could not be penetrated, and the contractor feared that the drill string was taking the path of least resistance into the clay layer. The article never said which type of drill bit was used. Ultimately, a second small sized drill rig was brought to the jobsite and placed on the north side, the pipe side. It punctured the rock, and entered the original bore. The contractor was then able to push the original drill string back to the original sending pit. After the troubles encountered with this pilot bore, there was little difficulty in the backreaming and pipeline pullback operations.

Chapter 6: Conclusion and Recommendations

It seems clear that horizontal directional drilling should be one of the first choices when considering construction of a utility under 6000 feet in length and 48” in diameter. While some limitations of frac-outs, flowing groundwater, cobbles and gravel beds may take time to be conquered by advancing technology, these situations can be avoided at times by selecting alternate pipe routes. New and in-progress ideas and innovations will continue to allow HDD to be state of the art for some time.

In 1996, sewer lines on grade began to be installed using HDD as surveying instruments were improved to detect pitch to an accuracy of less than 0.1%. The recent formation of the Directional Crossing Contractors Association (DCCA) along with efforts of the Trenchless Technology Center and Missouri Western State College should continue to help share knowledge about the industry and promote professionalism through perhaps an eventual licensing program for all directional drill rig operators. Wire less steering is being developed by different companies and should be on the market this year. Wire less steering will eliminate the need for a wire and a receiver. The transmitter and base station at the drill rig will communicate via antennas which will be mounted on tripods

and will be located along the drill path. As mentioned in the Challenges chapter, work is being done to mount a sensor on the drill bit to indicate whether utilities are near and what soil conditions are. Compressed air is being studied to evaluate whether it can take the place of drilling fluids. Of course, new drill rigs are developed all of the time - specifically to meet the needs of any type of crossing. These types of ideas should continue to keep the cost of horizontal directional drilling beneath the *Engineering News Record* construction cost index increase for some time.

It is recommended that HDD be the first alternative when crossing any waterway or wetland. Not every environmental agency requires its use yet, but the cost, time, environmental and social benefits cannot be overlooked. It should also be the first choice when planning for utility construction in smaller urban and suburban areas, with limits being size of line, soil conditions, and whether there is room for equipment set up. Currently, HDD is more capable of servicing smaller towns like Wichita, Kansas (1996 population of 320,000) and Des Moines, Iowa (1996 population of 193,000). Larger cities and urban areas should not be ruled out; however, the size of many lines would be too large and the space required by

a large rig area could also be a restrictive factor. That being the case, directional drilling should still be looked at for use on lateral lines and in areas surrounding the city.

Overall, the evidence in this paper supports the use of horizontal directional drilling. It is still a relatively new application, and there are users who are still unaware of the benefits provided by this technology. Those who are knowledgeable of the subject should continue to promote it and its various applications.

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Appendix

The Appendix includes a sampling of equipment specifications for the entire range of major components required by horizontal directional drilling. It is ordered as follows:

- Vermeer small and mid-size directional drills
- American Directional Drill small, mid-size and large directional drills
- Texas Pup drill pipe
- Parchem drilling fluid
- American Directional Drill recycling/mixing/pumping systems
- Surface to Surface stand alone mixing systems
- DCI transmitter specifications
- Sharewell tungsten carbide inserts,milled tooth bits
- Sharewell mud motors
- Surface to Surface reamers
- Sharewell lo-torque hole openers
- Surface to Surface pipe rollers
- Sharewell swivels

	Type	Torque	Pullback	Mud Flow	Length	Width	
D50x100A	Self-contained	10,000 ft-lb (13,560 Nm) @ 80 RPM	49,600 lbs. (22,499 kg)	135 gpm (511 Lpm) @ 1,200 psi standard	21' (6.4 m)	77" (196 cm)	D50x100A
		7,600 ft-lb (10,300 Nm) @106 RPM		78 gpm (295 Lpm) @ 1,800 psi optional			
		3,300 ft-lb (4470 Nm) @ 160 RPM 3-speed gearbox					
D40x40	Self-contained	4000 ft-lb (5415 Nm) @ 130 RPM	40,000 lbs. (18,144 kg)	60 gpm (227 Lpm)	22' (6.7 m)	93" (236 cm)	D40x40
		3000 ft-lb (4061 Nm) @ 174 RPM					
		1330 ft-lb (1801 Nm) @ 262 RPM					
D24x40A	Self-contained	4,000 ft-lb (5424 Nm) @ 131 RPM	23,800 lbs. (10,796 kg)	19 gpm (72 Lpm) @ 1600 psi	203" (516 cm)	74" (188 cm)	D24x40A
		3,000 ft-lb (4060 Nm) @ 174 RPM		38 gpm (144 Lpm) @ 800 psi (2-speed valve)			
		1,300 ft-lb (1760 Nm) @ 262 RPM 3-speed gearbox					
D24x26	Self-contained	2600 ft-lb (3520 Nm) @ 130 RPM	23,800 lbs. (10,796 kg)	option 1 - 28 gpm (106 Lpm)	203" (516 cm)	79" (201 cm)	D24x26
		1300 ft-lb (1760 Nm) @ 260 RPM		option 2 - 19/38 gpm (72/144 Lpm)			
				option 3 - Use any remote high-pressure drilling fluid system.			
D16x20	Self-contained	2000 ft-lb (2712 Nm)	16,000 lbs. (7,258 kg)	13.5 gpm @ 750 psi	188" (478 cm)	36" - 49" (91 cm - 124 cm)	D16x20
D10x15	Self-contained	1500 ft-lb (2031 Nm) @ 135 RPM	10,000 lbs. (4536 kg)	option 1 - 13.5 gpm (51.1 Lpm)	188" (478 cm)	36" - 49" (91 cm - 124 cm)	D10x15
		1000 ft-lb (1354 Nm) @ 180 RPM		option 2 - Use any remote high-pressure drilling fluid system		w/rod loader: 42" - 49" (107 cm - 124 cm)	
D7x11A	Self-contained	1100 ft-lb (1505 Nm)	7,800 lbs. (3,538) kg	9 gpm (34 Lpm) @ 500 psi	w/ water tank - 159" (404 cm)	35.5" - 49" (90 cm - 124 cm)	D7x11A

For additional information consult your local dealer or contact us.

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American Directional Drill has units on every continent except Antarctica. Pipeliners in China, Australia, Russia, Argentina, Nigeria and Germany are among the foreign users of our larger drills. American Augers pioneered large directional drills for river crossings. A DD-550, with 550,000 pounds of pullback force, was delivered in March, 1991. Small directional drills are the newest part of the companys American Directional Drill product line. Much of the drills uniqueness and many of their innovations come from American Directional Drills experience with larger drills. The company was the first manufacturer to eliminate chain and use rack and pinion for its carriage drive. No other manufacturer delivers as much fluid and rotary downhole horsepower. Just like our auger boring machines, the small drill specifications are conservative. The drills are rated for simultaneous maximum pullback, torque and drilling fluid flow.

Model	Thrust Pullback	Rotary Torque	Configuration
DD-1	10,000 lb	1,300 ft-lb	Self Contained, 54 HP engine
DD-15	15,000 lb	1,800 ft-lb	Modular with mud system & trailer
DD-25	25,000 lb	2,500 ft-lb	Modular with mud system & trailer
DD-50	50,000 lb	6,300 ft-lb	Modular, 54" wide, diesel tramming engine
DD-5	50,000 lb	10,000 ft-lb	Self contained, rubber track, pipe loader
DD-60R1	60,000 lb	12,000 ft-lb	Self contained, track mounted, uses 20' pipe
DD-60R2	60,000 lb	12,000 ft-lb	Self contained, uses 30' pipe, Cat 3126 engine, 260 HP
DD-90B	100,000 lb	20,000 ft-lb	Self contained, dozens in service around the world
DD-140B	140,000 lb	25,000 ft-lb	Self contained, track mounted, Cat 3306 engine, 300 HP
DD-220	220,000 lb	45,000 ft-lb	Self contained, 100 metric tonnes, Cat 3412 engine, 750 HP

River crossing maxi-rigs from the world's foremost builder of large directional drills. 1998 marks our tenth year in the directional drill business. A high degree of customization is also available, including trailer type, electric power in lieu of diesel, etc.

Model	Thrust Pullback	Rotary Torque	Configuration
DD-180	180,000 lb	30,000 ft-lb	Trailer mount
DD-330HP	330,000 lb	48,000 ft-lb	Skid, track or trailer mount
DD-550	550,000 lb	88,500 ft-lb	Skid, track or trailer mount
DD-660	660,000 lb	88,500 ft-lb	Skid, track or trailer mount
DD-1300	1,300,000 lb	100,000 ft-lb	Skid, track or trailer mount

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Voice: 800-645-4213
Fax: 318-367-1529
Email: info@texaspup.com

Looking for a competitive edge in directional boring? Replace your worn drill strings with rugged, long-life Bulldog trenchless drill pipe. No matter what kind of drilling rig you use, Bulldog forged pipe gives you the performance you need to improve efficiency, reliability and cost-effectiveness:

- **Strength** to handle the extreme torque, pushing and pulling forces of your toughest boring and backreaming applications
- **Flexibility** for effective steering
- **Rigidity** to resist bending
- **Durability**, in both the pipe body and connections, for longer service life

Bulldog pipe gives you a drill string you can rely on in any application - and a drill string that lasts longer than any other in the field. So you get greater overall economy and lower boring cost per foot.

Why Forging is Better

Bulldog pipe is made only by high-temperature forging. That's because pipe with welded connections has weak areas - the heatlines - where the chemical structure of the pipe and weld material are different. Since the connection is where working stresses are greatest, this is where most failures occur.

Forged pipe is formed from a single piece of premium steel. High-temperature forging moves material to the pin and box ends of the pipe without changing the microstructure of the metal. So the pipe body and connections are uniformly strong.

Any Size, Any Connection

Bulldog pipe is available to fit any drilling rig, in sizes from 1.660 through 27/8 inches OD in standard and metric lengths. We'll match your specifications and connections - and give you stronger, more durable forged construction.

QD - 65™ Connections

Only Texas Pup gives you the option of choosing robust QD-65 connections - designed specifically for the demands of directional boring:

- Allows fast make-up and break-out
- High torque and tensile strength
- Deep threads for ruggedness and durability
- Re-threadable for maximum economy
- Easy-to-install conversion kits allow any drilling rig to use Bulldog pipe with QD-65 connections.

QD-65 Conversion Kit

Many Drilling Contractors prefer Flush-Joint Pipe. The Smooth profile has less drag during pullback. Plus, the long internal connection adapts to multiple break-out systems.

Description: <u>Technical Data</u> <u>Chemical Analysis</u>	Pargel-220 is a polymer-extended, high yield (typical sample:min. 220 bbl./ton) sodium bentonite. Pargel-220 acts as a viscosifier and filtrate reducer in freshwater based drilling fluids. Pargel-220 has been used on more than 2.5 million feet of horizontal bores.
Recommended Uses:	For use where a specially formulated high yield bentonite is required, such as where river crossing, pipeline, utilities and other infrastructure reconditioning is being performed.

Features and Benefits:

- Quick mixing and high yielding.
- Improved bore cleaning.
- Maximum cuttings suspension.
- Insures greater bore hole stability in unconsolidated formations.
- Forms a thin, impermeable filter cake to reduce fluid loss.
- NSF® approved.
- Environmentally friendly, therefore non-fermenting and non-toxic.
- Typical sample yields 220 bbl./ton.

Recommended Treatment:

- Pargel-220 can be mixed at 8-20 lb./bbl. in fresh water:
- 20-25 lbs. per 100 gallons of make up water for "normal" soil conditions.
- 35-50 lbs. per 100 gallons of make up water when heavy cuttings are encountered, such as excess sand and gravel.

Note: Parchem recommends mixing 2 lbs. Soda Ash per 100 gallons of make up water before mixing Pargel-220, where make up water is hard (elevated calcium/magnesium).

Packaging:	Pargel-220 is packaged in 50 lb. sacks (22.7kg), 60 sx. per pallet, and also bulk sacks in 2,000 to 3,500 lbs.
Availability:	Pargel-220 can be purchased by calling **800-731-7331**, 24 hours per day, 7 days a week, from anywhere in the country.

PARGEL-220 TECHNICAL DATA SHEET (NSF® Approved)

Description:	Polymer Extended Sodium Bentonite
Application:	Specially modified for Horizontal Drilling or wherever a minimum 220 barrel yield is required. Pargel-220 is rapid response material especially noticable in cases of high volume requirements or where blending facilities are limited.
Typical Yield:	Pargel-220 will yield a minimum of 220 barrels of API 15cp fluid to one ton of material.

Specifications	Typical analysis
Fann @ 600 rpm	30.0 (Min.)

Filtrate	16 - 20 ml.
Moisture	10.0 maximum
Dry Sieve Analysis	75 - 80% (-200 mesh)
Wet Sieve Analysis	2.5 - 3.5% (-200 mesh)
pH	7 - 9

Note: Suspension, 9.2 grams Pargel-220 mixed to 350 ml. of distilled water. NSF® is the registered trademark of the National Sanitation Foundation.

The information contained herein is based on tests believed to be reliable, however, no warranty is implied.

PARGEL-220 CHEMICAL ANALYSIS

Chemical Name: Sodium Bentonite-Polymer Extended

Product Use: Designed specifically for Horizontal Drilling, Water Well Drilling, Seismological Drilling or where a specially selected, fast response, high yield, Premium Wyoming Bentonite is required.

Typical Chemical Analysis

Silica (SiO2)	61.37%
Alumina (A1203)	21.35%
Ferric Oxide (Fe203)	3.10%
Ferroud Oxide (FeO)	.13%
Lime (CaO)	.45%
Magnesia (MgO)	2.65%
Soda (Na2O)	2.39%
Potash (K2O)	.31%
Water (H2O+) (chemically bonded)	4.84%
Water (H2O+) (mechanically held)	8.00-9.50%
Titanium Dioxide (TiO2)	.12%
Ignition Loss	6.21%
Fusion Point	2440 degrees F.

Material Safety Data Sheet (MSDS) for this product is available.

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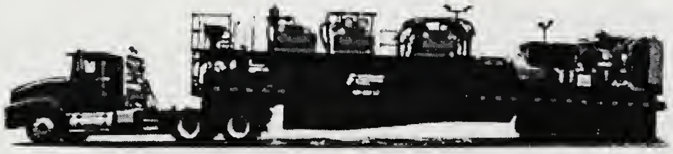
AMERICAN
DIRECTIONAL DRILL



Our American Directional Drill division designs and manufactures mud pumping and mud cleaning systems. Systems are supplied with our smaller directional drills. Large capacity systems are available for use with any brand of drilling equipment. All modern state-of-the-art directional drills use a drilling fluid system. American Augers pioneered the use of drilling mud in trenchless construction in the late 1970s. (Bentonite, drilling fluid and mud are all terms for the same thing.) In smaller diameter holes under certain job conditions, some contractors have been able to use water alone. But it is becoming increasingly clear through the experiences of directional drill contractors all over the world that the proper use of drilling mud is a very important to being consistently successful in directional drilling. It can greatly increase boring distances, especially in sand. Bentonite is a clay-like mineral that can be dissolved in water to form a slippery liquid for use by drillers. Special bentonite pumps force this mixture underground through the drill pipe to help ease friction and allow for longer bores. It not only serves as a lubricant but helps control the loss of water from the drilling fluid into the surrounding soil, and flushes cuttings out of the bore. Re-use of the fluid reduces the cost of adding bentonite and prolongs the life of components due to reduced abrasion. The solid material removed from the mud has a very low moisture content, reducing its volume and making it eligible for disposal in most landfills. Therefore, the contractor can benefit from the liberal use of drilling mud without being penalized with excessive bentonite or disposal costs.

Fluid (mud) cleaning/recycling/mixing systems

Model	Cleaning Capacity	Tank Capacity	Configuration
MCM-500	100 gal/min	600 gal (2271 lit)	Skid or trailer
MCM-1000	250 gal/min	1000 gal (3785 lit)	Skid or trailer
MCM-1800	250 gal/min	1800 gal (6813 lit)	Skid or trailer
MCM-6000	600 gal/min	6000 gal (22710 lit)	Skid or trailer

American Directional Drill Model	EWCO Triplex Pump	Bore x Stroke Inch (mm)	Engine	HP (kW)	Estimated Output	Estimated Output
P-250	W-250-C	5 x 5 (127x 127)	Cat 3306	300 (223.8)	270 GPM @ 1,500 PSI	1000 lit/min @ 105.5 bar
	W-250-C	5 x 5 (127x 127)	Cat 3406	440 (328.2)	400 GPM @ 1,000 PSI 400 GPM @ 1,500 PSI	1500 lit/min @ 103.4 bar 1500 lit/min @ 105.5 bar
P-446 Superforce	W-446	6 x 6 (152 x 152)	Cat 3406	440 (328.2)	400 GPM @ 1,500 PSI 660 GPM @ 900 PSI	500 lit/min @ 105.5 bar 2500 lit/min @ 63.3 bar
	W-446	6 x 6 (152 x 152)	Cat 3408	500 (373)	450 GPM @ 1,500 PSI 660 GPM @ 1,000 PSI	1700 lit/min @ 105.5 bar 2500 lit/min @ 103.4 bar
	W-446	6 x 6 (152 x 152)	Cat 3412	750 (559.5)	660 GPM @ 1,600 PSI	2500 lit/min @ 112.5 bar

Fluid (mud) pumping/cleaning/mixing systems

Model	Pumping Capacity	Cleaning Capacity	Tank Capacity	Pump Type
MP-135	135 gal/min	100 gal/min	3000 gal (11355 lit)	FMC
MP-270	270 gal/min	250 gal/min	4000 gal (15140 lit)	FMC
MP-300	300 gal/min	300 gal/min	6000 gal (22710 lit)	Aplex
MP-400	400 gal/min	400 gal/min	6000 gal (22710 lit)	Ellis Williams

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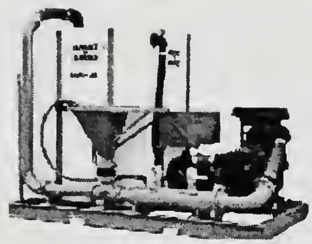
SURFACE TO SURFACE
DIRECTIONAL DRILLING SYSTEMS

Stand Alone Mixing Systems

The SAM series of Bentonite mixing systems, were developed for the horizontal directional drilling industry, primarily intended for use with the mini, and small drill rigs. The unique shear and mixing at 4 points during circulation have proven during testing that the patent pending Venturi / Jetting mixing system works equally well with the requirements of the larger drill rigs. Larger mixing systems will be offered on a special order basis , tell us what size you want.



SAM - 500 gal. SENIOR

500 gal. Welded Rectangular Polyethelyne Tank c/w 18 inch top manhole and steel tubular frame - Robin EH63 Rated @ 18.0 hp @ 3600 rpm air cooled , gasoline engine, electric start -- Monarch TSP 4 in. cast iron, centrifugal trash pump capable of 616 gpm @ 30 pounds of head - High Vacuum Anti Bridging Dry Hopper and table assy. - 4 in. Mixing Tee and Venturi Jet - Filter / Shear assy. complete with removeable inner stainless steel cartridge for cleaning - Tank Mounted Jet Guns.

Dimensions - 61 inches wide x 94 inches long x 76 inches high

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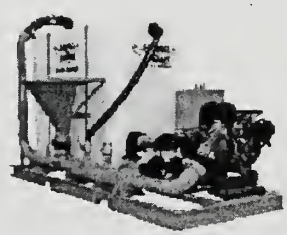

SAM - 300 gal. JUNIOR

300 gal. Roto - Molded Rectangular Polyethylene tank c/w 18 inch top manhole - Robin EH30D Rated @ 9.0 hp @ 3600 rpm air cooled, gasoline engine, manual start - Monarch TSP 3 inch cast iron, centrifugal trash pump capable of 318 gpm @ 30 lbs. of head - High Vacum Anti Bridging Dry Hopper and table assy. - 3in. Mixing Tee and Venturi Jet - Filter/Shear assy. c/w removeable inner stainless steel cartridge for cleaning - Tank Mounted Jet Gun.

Dimensions - 46 inches wide x 96 inches long x 60 inches high

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Operating

Fill tank with water--open butterfly valve on suction line--start engine--set speed to run position--open jet gun valve--close discharge valve--open hopper butterfly valve--pour bentonite into hopper--vacuum will introduce dry material into the jet stream--continue adding bentonite until the desired consistency is achieved. When mixed product is ready for delivery to the high pressure pump -- attach a transfer line to the discharge valve located on the shear/filter housing and open ball valve for delivery of mixed slurry to the high pressure pump or holding tank.

Note - We have provided in the mixing tee, located under the hopper, a threaded vacuum port. There is 25 to 30 inches of vacuum present at this port, and can be used to add water to the tank or introduce reclaimed slurry to the mix without additional pumps.

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®DIGITAL CONTROL INCORPORATED

Mark III Transmitter Specifications

Model Color	Length x Diameter	Depth Range	Battery Type	Temperature Rating	W
DS	8 in. x 1.00 in 20 cm x 3.125 cm	15 ft 4.6 m	1 AA-cell alkaline 12 hours awake 50 hours sleep	180°F (82°C)	8 2
DT	15 in. x 1.25 in 38 cm x 3.125 cm	40 ft 12.2 m	2 C-cell alkaline 30 hours awake 200 hours sleep	220°F (104°C)	6
DX	15 in. x 1.25 in 38 cm x 3.125 cm	70 ft 21.3 m	2 C-cell alkaline 20 hours awake 200 hours sleep	220°F (104°C)	6
D4X	19 in. x 1.25 in 48 cm x 3.125 cm	70 ft 21.3 m	4C-cell alkaline 40 hours awake 400 hours sleep	220°F (104°C)	1 8
D4XP	19 in. x 1.25 in. 48 cm x 3.125 cm	70 ft 21.3 m	4 C-cell alkaline 40 hours awake 400 hours sleep	220°F (104°C)	1 8
DXP	15 in. x 1.25 in. 38 cm x 3.125 cm	70 ft 21.3 m	2 C-cell alkaline 20 hours awake 200 hours sleep	220°F (104°C)	6
DC	15 in. x 1.25 in. 38 cm x 3.125 cm	140 ft 42.7 m	12V to 28V DC cable power	180°F (82°C)	5
DCP	15 in. x 1.25 in. 38 cm x 3.125 cm	140 ft 42.7 m	12V to 28V DC cable power	180°F (82°C)	5

Depth Range = 25% less with Mark II

Frequency = 33 kHz

Pitch Update = 2-1/2 seconds

All achieve Sleep Mode after 15 minutes (except DC and DCP)

All give digital display of temperature and percent of battery life remaining

Accurary = +/- 5% abs

Roll Update = 1/4 secoı

DC, DCP Roll and Pitc from Cable

Click here for more details

Bits

Sharewell's experience in horizontal drilling has resulted in custom designs and customer satisfaction in drill bit selection. All of Sharewell's premium bits are manufactured by Walker McDonald to provide the highest penetration rates and longest life in any formation.

TUNGSTEN CARBIDE INSERT

Tough sintered tungsten carbide inserts resist wear and breakage. Bit types for formations range from ultra-soft to extremely hard. Close attention to insert material composition of gage, inner row, and nose areas optimize cutting structure performance. Sealed journal bearing TCI bits are offered in a wide range of formation configuration sizes up to 12 $^1/_4$" inch. Bits can be lugged for use with motors and in abrasive formations.

SOFT FORMATION

Aggressive, long conical and chisel-shaped, inserts for soft to medium formations.

MEDIUM FORMATION

Moderate, extension conical and chisel-shaped inserts for medium to hard formations.

HARD FORMATION

Minimal extension, ovoid-conical and hemispherical dome for hard formations.

MILLED TOOTH

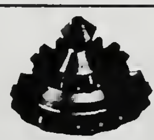
ɪr McDonald's steel tooth bits are constructed with the same ;tandards as our TCI bits. This line of milled tooth bits in sealed ıl and open roller bearing types, are designed to provide high ration rates, durability and low drilling costs.

RA-SOFT FORMATION

ssive design with deeply intermeshed teeth naximum cone offset for sands, clays and soft formations.

IUM SOFT & MEDIUM FORMATION

ısed tooth counts for soft formations with ım to medium-hard streaks.



D FORMATION

ed hard cutting structure for hard, semi- ive formations where milled tooth can be mically used.

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Directional Drilling Systems
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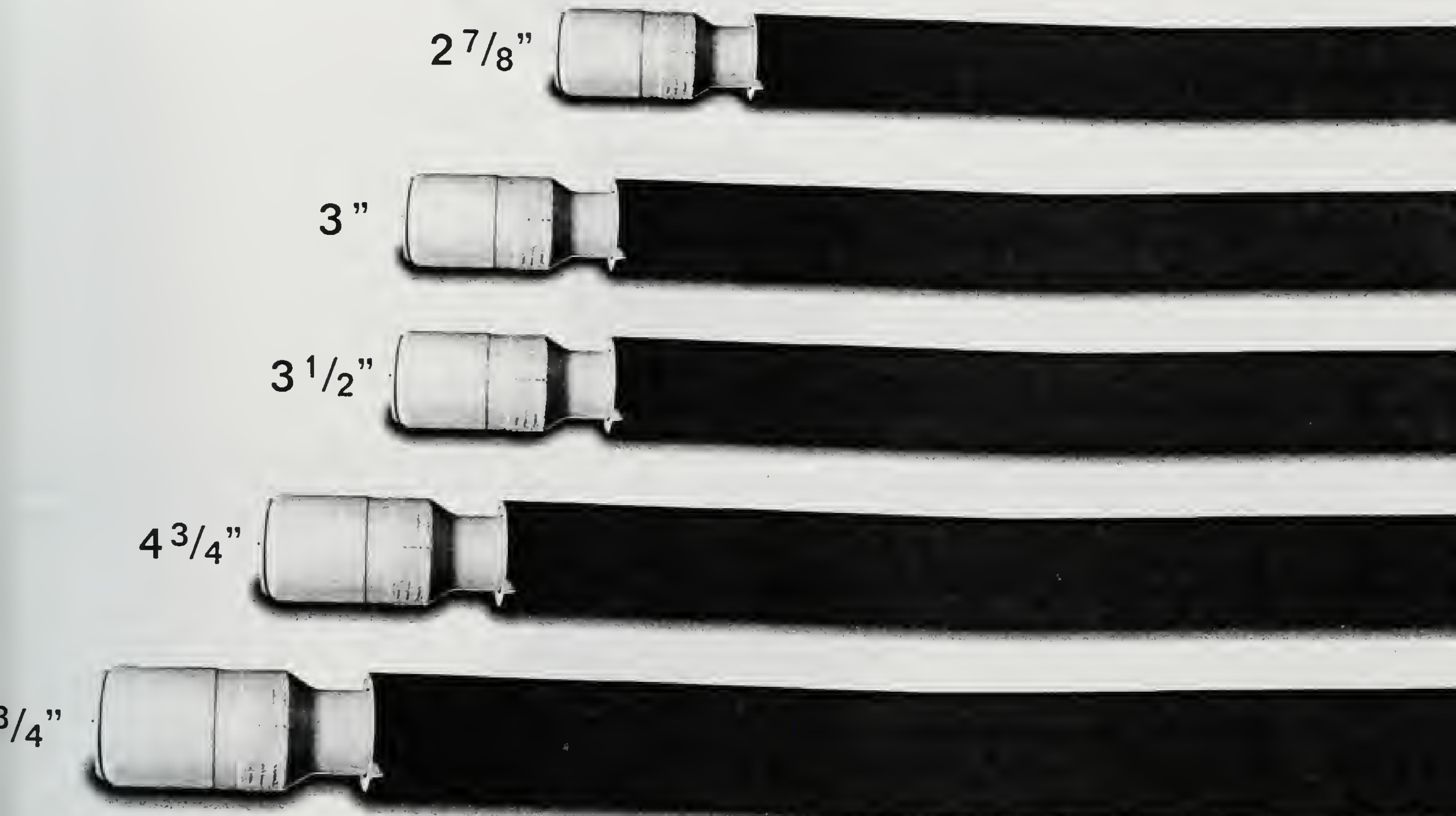
Eastern Hemisphere • Phone: ++44-1224-771244 • Fax: ++44-1224-771204

Mud Motors

Sharewell provides the most durable and economical drilling motors available to pipeline and utility contractors. We offer a complete line of small (low flow) motors and larger (high flow) motors specifically designed to meet flow requirements on any size directional rig.

Whether you desire to purchase motors, lease motors or have a single job application, Sharewell's Rock Drilling Systems Group will assist you to ensure success and profitability in your directional drilling applications.



LOW FLOW MODULAR MOTOR

Tool Size O.D.	Connections	Bit Size	Flow G.P.M.	R.P.M. No Load	Torque Ft. Lbs.	Operating Differential PSI
3" LF	Top: 2 3/8" Reg Bottom: 2 7/8" Reg	4" - 5 1/2"	45	280	250 ft-lbs	750

STANDARD MOTORS

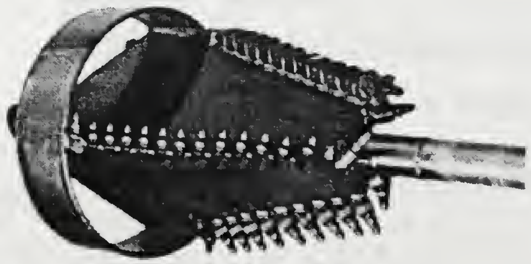
Tool Size O.D.	Connections	Bit Size	Flow G.P.M.	R.P.M. No Load	Torque Ft. Lbs.	Operating Differential PSI
2 3/8"	1 1/4" Reg	2 7/8" - 3 1/2"	42	850	120 ft-lbs	750
2 7/8"	2 3/8" Reg	3 1/4" - 4 3/4"	90	640	265 ft-lbs	750
3 1/2"	2 7/8" Reg	3 7/8" - 4 3/4"	160	375	1050 ft-lbs	500
4 3/4"	3 1/2" Reg	6 " - 7 7/8"	250	165	2100 ft-lbs	500
6 3/4"	4 1/2" Reg	7 5/8 " - 10 5/8"	650	185	6000 ft-lbs	500

Sharewell, Inc.
Directional Drilling Systems

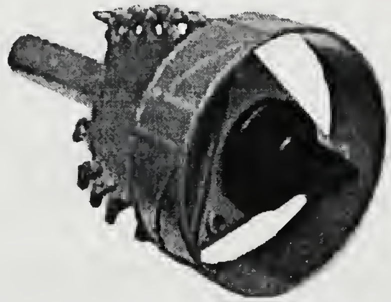
6829 Flintlock Road • Houston, TX 77040 U.S.A. • Phone: (800) 637-6461 / (281) 892-9818 • Fax: (281) 892-9820
rilex House • 17 Howe Moss Drive • Kirkhill Industrial Estate • Dyce, Aberdeen AB2 OGL • Scotland • Phone: ++ 44-1224-771244 • Fax: ++ 44-1224-771204

SURFACE TO SURFACE
DIRECTIONAL DRILLING SYSTEMS

HOLE OPENER- REAMERS



Tri - Reamers available in 8 inch to 22 inch diameters



The reamers shown here are designed for use in soil conditions with some cobbles and stones, but should not be confused with rock reamers. We also build numerous other designs including Spiral Compacting Reamers and Fly Cut Reamers. The perfect reamer to cut all soil types has not been developed, however we are trying. "We can custom build the reamer you want!"

Blade-Reamer 6 in. to 12 in.

All STS soil reamers are built to high standards for durability and service life. Our reamers are all built using a full length mandrel (no welded on stub ends), all wear area's are hard surfaced , replaceable carbide teeth are used where required. Our standard reamer lines have all been field tested for durability and reliability and are available with the popular thread patterns (special threads will require a sample).

Other reamer designs are available or "We can build a reamer to your particular design", just submit a sketch or drawing for pricing.

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Dealer Inquiries Welcomed

o-Torque Hole Opener

FOR UNDERGROUND CONSTRUCTION

- Designed to ream in any formation
- Lowers drill string torque allowing small rigs to ream in rock formation
- Single tool body can open up to four different hole sizes
- Sealed journal bearing cutters are field replaceable while on drill string
- Unique slick body design decreases common repair costs associated with conventional reamers and hole openers
- Available in push or pull style bodies
- All cutters gage protected for optimum wear resistance
- Cutters are available in milled tooth for soft to medium rock formations or Tungsten Carbide Inserts (TCI) for hard rock formation

BODY					CUTTERS				
Minimum Pilot Hole	Approx. Length	Approx. Weight	Connections Pin	Connections Box	Number Of Cutters	Hole Sizes			
2 1/2"	15"	30	1 1/4 reg	1 1/4 reg	3	6"			
4 1/2"	26"	100	2 3/8 IF	2 3/8 IF	3	8"	10"	12"	
6 1/2"	31"	200	3 1/2 IF	3 1/2 IF	3	12"	14"	16"	
8 1/2"	36"	450	4 1/2 IF	4 1/2 IF	3	16"	18"	20"	22"
16"	42"	1000	7 5/8 reg	7 5/8 reg	3	24"	26"	28"	30"
24"	42"	1200	7 5/8 reg	7 5/8 reg	4	32"	34"	36"	38"
32"	42"	1400	7 5/8 reg	7 5/8 reg	4	40"	42"	44"	46"
40"	42"	1600	7 5/8 reg	7 5/8 reg	4	48"	50"	52"	54"
48"	42"	2000	7 5/8 reg	7 5/8 reg	5	56"	58"	60"	62"

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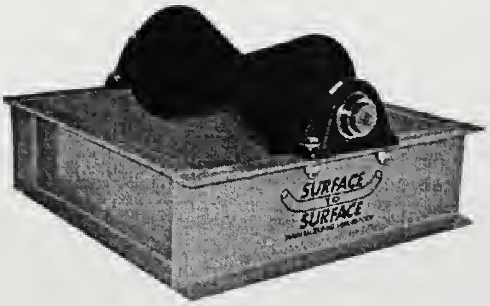
PIPE ROLLERS



PR-10/18 PIPE ROLLER

The PR-10/18 pipe roller is a heavy duty roller built for the construction trade, to provide years of trouble free service. This roller has a load capacity of 3000 lbs. and is built on a sturdy 8 inch steel channel frame, the rollers are solid molded urethane with a 2 inch full length mandrel supported on pillow block bearings. This roller design is suitable for use with 6 inch to 30 inch diameter plastic or steel pipe.

The PR-3.75/6.75 pipe roller is a heavy duty light weight roller designed for use by the construction trade, to provide years of trouble free service. This roller has a load capacity of 1000 pounds and is built on a sturdy channel frame,the rollers are solid molded urethane with a 1 inch full length mandrel supported on Yas pillow block bearings. This roller design is suitable for use with 2 inch to 8 inch plastic or steel pipe and was designed to protect coated pipe from scaring due to dragging .

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DCD
Sharewell

DUB-Swivels® – 00508 series These Pullback Swivels are designed specifically for Directional Drilling applications.

The single most important feature of this patented product is the sealing system. The multiple sealing stages become progressively finer such that an oil seal is not required to keep out sand and other coarse particles which can easily destroy such a simple lip seal. This is done by much sturdier seals designed for use in such applications as cement mixers or military tanks used in desert conditions.

In addition to the sealing system, these swivels offer a lubrication system complete with relief valve so that the seals cannot be damaged by over greasing. Grease need only be applied in small quantities since loss of lubricant is almost non-existent.

The type of bearings used vary depending on swivel type and size. The Type 1 swivels utilize Spherical, Cylindrical and Tapered Roller Bearings designed to provide an extra measure of side load capacity caused by the threaded or solid connection. The Type 2 swivels use back to back Tapered Roller Bearings in the smaller sizes, but again the 80,000 lb. and 160,000 lb. units utilize the same Spherical, Cylindrical and Tapered Roller Bearings as the Type 1 swivels.

All mechanical components are designed to withstand a straight tensile load of 5 times the Safe Working Limit.

DUB-Swivels®
Type 1
API Box / Clevis

Type 1 swivels offer an API box connection at the leading end and a Clevis connection at the trailing end.

All these swivels are built with individually assigned serial numbers and complete material traceability for every component.

DUB-Swivel Part No.	Safe Working Limit	Ultimate Load	Max Dia.	Length	Weight	API Thread Size*
00508-130	60,000 lb.	300,000 lb.	6"	19-7/16"	98 lb.	2-7/8" IF
00508-140	80,000 lb	400,000 lb	6-1/2"	26-1/8"	175 lb.	4-1/2" IF
00508-160	120,000 lb.	600,000 lb.	7-1/2"	28-1/2"	325 lb.	4-1/2" IF
00508-180	160,000 lb.	800,000 lb.	9"	34-3/16"	450 lb.	4-1/2" IF
00508-1150	300,000 lb.	1,500,000 lb.	12-1/2"	44-1/8"	848 lb.	6-5/8" REG.
00508-1250	500, 000 lb	2,500, 000 lb.	16"	54-1/8"	1767 lb.	7-5/8" REG.

* Thread sizes shown are standard, other size available on request.

DUB-Swivels®
Type 2
Clevis / Clevis

Type 2 swivels offer a Clevis connection at both ends with hardened, lockable Clevis Pins.

Swivels 40,000 lb. capacity and larger have individually assigned serial numbers and complete material traceability for every component.

DUB-Swivel Part No.	Safe Working Limit	Ultimate Load	Max Dia.	Length	Weight	API Thread Size*
00508-202	5,000 lb.	25,000 lb.	2"	7-11/16"	3.9 lb.	**00508-202**
00508-205	10,000 lb	50,000 lb	3-1/8"	11-9/16"	15.5 lb.	**00508-005**
00508-210	20,000 lb.	100,000 lb.	3-3/4"	13-5/8"	27.5 lb.	**00508-010**
00508-220	40,000 lb.	200,000 lb.	5-3/4"	18-7/16"	82 lb.	**00508-020**
00508-230	60,000 lb.	300,000 lb.	6"	18-1/2"	84 lb.	**00508-020**
00508-240	80, 000 lb	400, 000 lb.	6-1/2"	24-5/16"	152 lb.	**00508-040**
00508-260	120, 000 lb	600,000 lb.	7-1/2"	26-3/4"	325 lb.	**00508-040**
00508-280	160, 000 lb	800,000 lb.	9"	33-15/16"	405 lb.	**00508-080**

(The bearings are designed to provide a lifespan in excess of 700 hours for smaller swivels and for the larger 300,000 and 500,000 lb. units, a lifespan in excess of 2000 hours is expected. These lifespans are based on proper usage of the swivel – severs side or shock loads may affect these expectations. Close attention must be paid to the product sheets that accompany each swivel shipped.)

It is our recommendation to always select a swivel <u>larger</u> than the machine capacity. This may cost a little more, but when this is done and the product is used carefully, lifespans in excess of 3000 hours have been recorded.

Sharewell
Directional Drilling Systems

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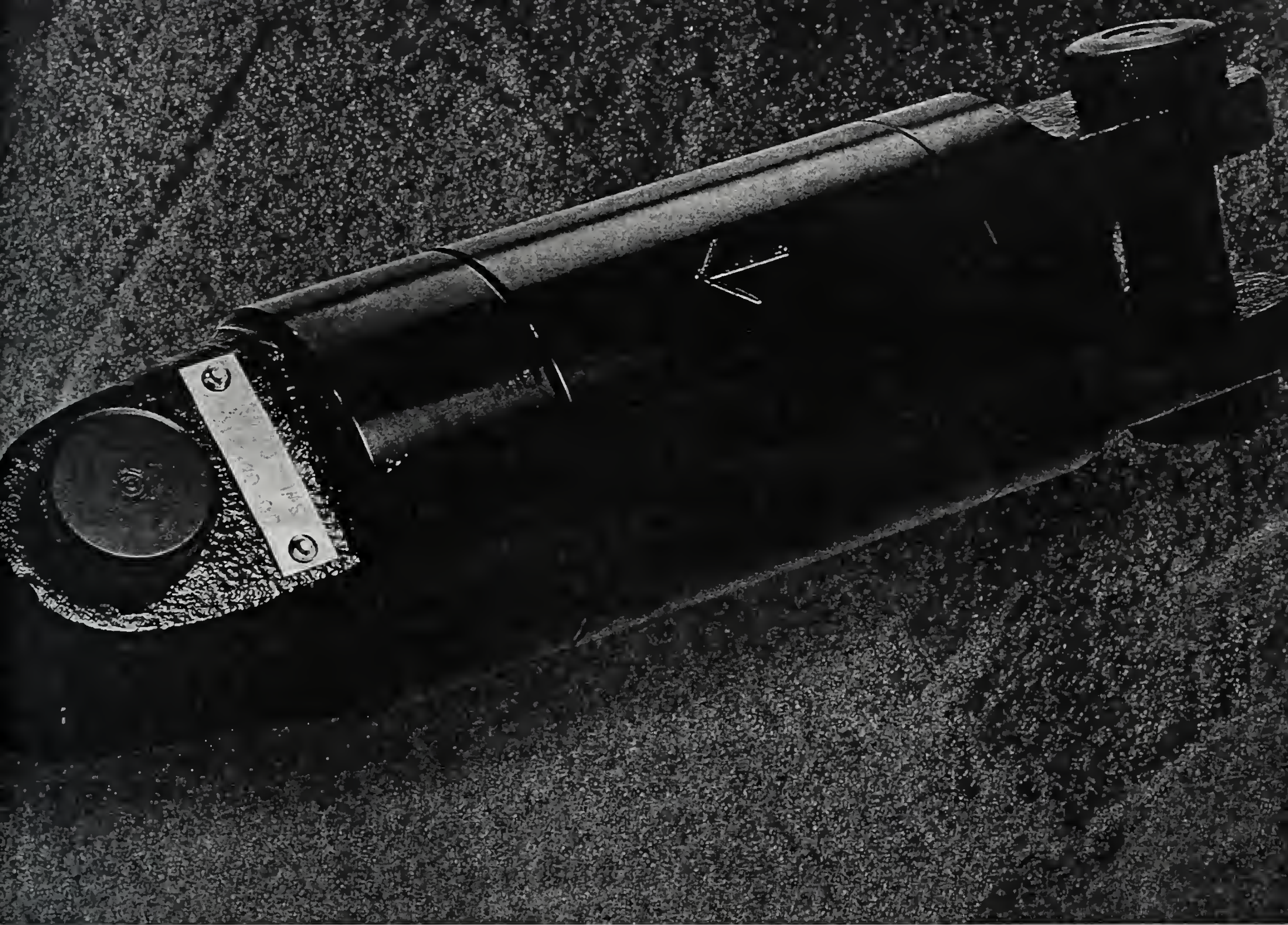
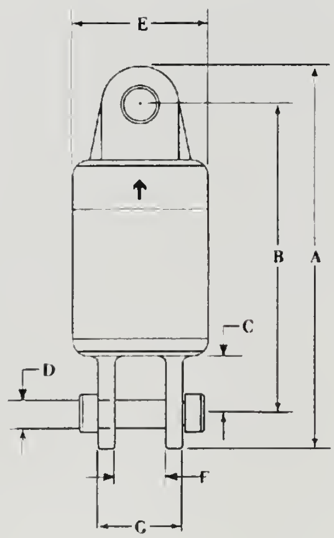


imensions

Part No.	A	B	C	D	E	F	G	WT.
)0508-202 5,000 lbs. 22.2 KN.	7-9/16" 192.1 mm	5-15/16" 150.8 mm	1-9/32" 32.5 mm	11/16" 17.5 mm	2" 50.8 mm	1-1/64" 25.8 mm	2" 50.8 mm	3.8 lbs. 1.7 kg.
)0508-205 10,000 lbs. 44.4 KN	11-17/32" 292.9 mm	9-25/32" 248.4 mm	1-11/16" 42.9 mm	3/4" 19.1 mm	3" 76.2 mm	1-9/32" 32.5 mm	2-9/32" 57.9 mm	15 lbs. 6.8 kg.
)0508-210 20,000 lbs. 88.9 KN	13-5/8" 346.1 mm	11-1/2" 292.1 mm	1-15/16" 49.2 mm	1" 25.4 mm	3-3/4" 95.2 mm	1-17/32" 38.9 mm	2-25/32" 70.6 mm	27 lbs. 12.1 kg.
)0508-220 10,000 lbs. 177.9 KN	18-7/16" 468.3 mm	14-15/16" 279.4 mm	2-3/4" 69.9 mm	1-3/8" 34.9 mm	5-3/4" 146.1 mm	2" 50.8 mm	3-1/2" 88.9 mm	83 lbs. 37.6 kg.
0508-240 30,000 lbs. 355.8 KN	24-1/2" 622.3 mm	20" 508.0 mm	3-3/8" 85.7 mm	1-3/4" 44.5 mm	6-1/2" 165.1 mm	2-3/8" 60.3 mm	4-5/8" 117.5 mm	150 lbs. 68.0 kg.
0508-280 50,000 lbs. 711.7 KN	33-1/2" 850.9 mm	26-1/2" 673.1 mm	4-5/8" 117.5 mm	2-1/2" 63.5 mm	9" 228.6 mm	3-5/32" 80.2 mm	5-29/32" 150.0 mm	380 lbs. 172.0 kg.



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